Precipitation

Formation and Classification Measurement and Detection

Precipitation Formation

- Cloud drops form when water vapor condenses on small particles called cloud condensation nuclei. Those drops are too small to fall to the surface against the rising air that created the cloud. To get precipitation, some other process must create bigger drops or ice crystals.

- Much of the time the precipitation forms as a result of the **ice crystal process**.

- In portions of clouds above freezing (0 °C) there are liquid drops but no ice crystals. In portions of clouds between -20°C and -40 °C there are liquid drops and ice crystals. In portions of clouds colder than -40 °C, there are few liquid drops and more ice crystals

- The saturation vapor pressure around an ice crystal is slightly lower than the saturation vapor pressure around a liquid drop. This means that a water vapor molecule will deposit on an ice crystal before it will condense on a liquid drop.

- The ice crystals grow and some of the water drops evaporate. When the ice crystals grow large enough, they begin to fall toward the surface.

- If the ice crystals or raindrops collide, they may combine (coalesce). This is called the **collision-coalescence process**.
- This is an *inefficient* method of precipitation formation because it requires the droplets to collide with one another **AND** coalesce (bond).
- Many times the droplets bounce off each other

Types of Precipitation

- **Drizzle**: Small water drops from 0.2 to 0.5 mm in diameter that drift slowly towards the Earth's surface. Drizzle drops are usually relatively small because they form in stratus clouds which are low and thin. Drizzle is associated with fog and poor visibility but never with convective clouds.

- **Rain**: Water drops ranging from 1 to 6 mm in diameter. The bulk of rain the falls in middle and high latitudes originates as snow flakes.

- **Snow**: The air is below freezing down to the surface and the ice crystals reach the surface. All snow flakes are hexagonal (six-sided)

  At higher temperatures, snowflakes more readily stick together after colliding, thus causing larger flakes that may exceed 5 to 10 cm in diameter. This is usually a sign that the snow is about to turn to rain.

- **Ice Pellets (Sleet):** Frozen raindrops about 5 mm or less in diameter. There is a layer beneath the cloud with a temperature above freezing and a layer above the surface with a temperature below freezing. The ice crystals melt and then refreeze before they hit the surface.

- **Freezing Rain/Drizzle**: The air beneath the cloud is above freezing except the surface itself and possibly a thin layer above the surface. The ice crystals melt and reach the surface as liquid drops and then freeze on the surface.

- All of these forms of precipitation can occur within a 100 mile band

- Hail: Forms in the strongest updrafts of a thunderstorm. Water that collides with the original ice pellet (hail embryo) freezes and the hailstone grows through accretion. When the hailstone becomes too large, the updrafts can no longer support it and it falls to the surface

- Largest hailstone recorded in the U.S. fell in Coffeyville, Kansas in September 1970 weighing 1.5 lbs.
- Hail is most commonly found in Eastern Wyoming, Eastern Colorado, Western Nebraska and Western Kansas where it occurs an average of 6-10 days a year.

Measuring Precipitation

- **Standard Rain Gage**: Cone shaped funnel at top which directs rain water into a long narrow cylinder, which is seated inside a larger, outer cylinder.
- The funnel and narrow cylinder magnify the scale so that the instrument resolves rainfall to increments of 0.01 in. Rainwater is measured with a stick which requires human interaction
- During the winter months, the funnel is removed and only the outer cylinder is used. Snow is collected, then melted to measure water equivalency

- **Weighing Bucket Rain Gage**: records the weight of a accumulating rainwater on a drum (graph) or computer. Requires frequent calibration.
- During subfreezing weather, antifreeze is added to the drum to melt snow as it falls in the gage.

- Tipping Bucket Rain Gage: Funnel leads to two small metal containers which hold 0.01 in of rain. Bucket empties when full, causing a signal to be sent to the recording device.
- More precise than weighing bucket gage, but not good in heavy downdrafts.

Detecting Precipitation: Radar

- **Radar** is an acronym for **RA**dio **D**etection **a**nd **R**anging. Radar can scan a wide area continuously and can locate small, isolated areas of precipitation.

Radar: History

- Radar was first used during World War II for military purposes. Early weather radars were reconditioned short-range surplus military units.
- In the mid 1950s, following major tornado and hurricane disasters, the U.S. allocated funds for development of long range radar units. In 1959, these WSR-57 units were deployed along the Atlantic and Gulf coasts, and in the central U.S.
- By 1964, there were 32 sites across the U.S. In 1974, some sites were upgraded with the installation of WSR-74 units which introduced limited color enhancement and other features.
- In the mid 1990s, as part of the National Weather Service modernization program, over 110 WSR-88D Doppler radar units were deployed across the U.S. to replace obsolete WSR-57 and WSR-74 units.

Radar

- The WSR-88D is protected from the elements by a radome, a spherical structure composed of a material that protects the radar from wind and weather and is transparent to microwaves.
- The WSR-88D can operate in reflectivity mode or velocity mode:

Radar: Reflectivity Mode

- In this mode, the radar emits short pulses of microwave energy (about 10 cm). These radar signals are reflected and scattered by rain, snow, or hail, but not by the very small droplets or ice crystals that compose clouds. The signals are reflected and scattered back to the receiving unit and displayed as a radar echo (electrical pulse) on a computer screen

- In this mode, radar range is about 285 miles. Ultimately, this is limited by the curvature of the earth

- Radar can also detect swarms of insects that collect along boundaries within air masses, as well as birds.
- In addition, nearby objects, such as buildings, smokestacks, etc also reflect radar signals. These signals are known as **ground clutter**

- **Virga** is rain that falls into very dry air and evaporates before reaching the surface. Often, virga appears on the radar screen when no precipitation is actually falling at the observation station

Radar: Velocity (Doppler Mode)

- In this mode, the radar operates on the same principle as the device used to measure the speed of a baseball pitch. It is based on a principle of physics known as the Doppler Effect, which refers to a shift in the frequency of waves emanating from a moving source
- Doppler radar monitors the speed of precipitation (or dust) particles as the move radially away or toward the antenna. Doppler radar can monitor circulation within a weather system and sees inside clouds and thunderstorms. In this mode, radar range is reduced to about 143 miles.